

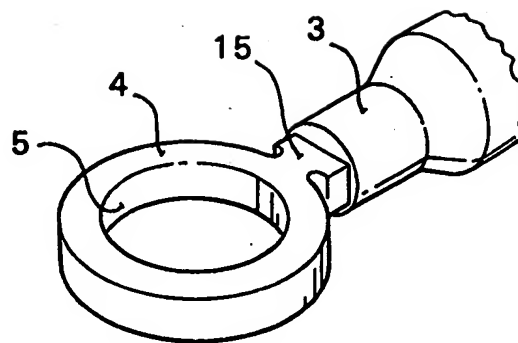
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>B06B 3/00</b>	<b>A1</b>	(11) International Publication Number: <b>WO 99/01235</b> (43) International Publication Date: 14 January 1999 (14.01.99)
<p>(21) International Application Number: PCT/IB98/00897</p> <p>(22) International Filing Date: 9 June 1998 (09.06.98)</p> <p>(30) Priority Data: 9702551-4 2 July 1997 (02.07.97) SE</p> <p>(71) Applicant (for all designated States except US): TETRA LAVAL HOLDINGS &amp; FINANCE S.A. [CH/CH]; Avenue Général-Guisan 70, CH-1009 Pully (CH).</p> <p>(72) Inventor; and (75) Inventor/Applicant (for US only): FREI, Karl [CH/CH]; Friedbergweg 7C, CH-9500 Wil (CH).</p> <p>(74) Agent: BENTZ, Christer, AB Tetra Pak, Ruben Rausings gata, S-221 86 Lund (SE).</p>	<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published With international search report.</p>	

(54) Title: AN ULTRASONIC ASSEMBLY INCLUDING AN ANULAR SONOTRODE

## (57) Abstract

In, for example, the welding of circular objects, for instance packaging containers, use is made of an ultrasonic assembly for circular sealing, the assembly including a transducer (2) and an annular sonotrode (4). The transducer is radially, mechanically connected to the sonotrode, possibly via a booster (3). In order to avoid heating and possible damage to the connection point to the sonotrode, this is provided, in the assembly according to the present invention, with an adapter portion (15) which is in the form of a projection (16) radially projecting from the sonotrode (4). At its end facing away from the sonotrode, the projection (16) is provided with an anchorage device (14) for direct or indirect mechanical connection to the transducer (2), and the adapter portion further displays a region, at its end facing towards the annular portion of the sonotrode (4), of reduced cross-sectional area, which together reduces the harmful effects of the ultrasonic waves on the anchorage region.



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## AN ULTRASONIC ASSEMBLY INCLUDING AN ANULAR SONOTRODE

## TECHNICAL FIELD

The present invention relates to an ultrasonic assembly  
5 comprising a transducer and a sonotrode.

## BACKGROUND ART

Ultrasonic vibrations in the frequency range of from 15,000 to  
50,000 Hz, are nowadays employed industrially for numerous purposes,  
10 including the welding of different types of materials, the treatment of  
liquids or other fluids, etc. The welding of plastic materials is a common  
task within the packaging industry and ultrasonic welding is, therefore,  
gradually extending its fields of application in the manufacture of  
different types of packaging containers, not only of pure plastic film or  
15 plastic material but also of different types of laminates which include  
outer layers of thermoplastic. Originally, the ultrasonic technique was  
only employed for relatively simple, rectilinear welds of planar material,  
but continued developments of the art have entailed that ultrasonic  
welding is now also employed for advanced welding operations, e.g.  
20 different combinations of materials and different types of non-linear  
welds in a plurality of dimensions.

A typical assembly for ultrasonic welding or sealing of the type  
employed in the packaging industry utilises a transducer for creating  
ultrasound of the desired frequency. The transducer may be of  
25 conventional type and include, for example, a piezoelectric crystal which  
is brought to oscillate by being connected to a suitable current source.  
Once the transducer has then taken care of the conversion from electricity  
to mechanical reciprocation, this movement is normally transferred by  
direct contact between the transducer and a booster which, because of its  
30 geometric architecture, amplifies the amplitude of the mechanical  
movement so that it is optimised for ultrasonic welding of, for example,  
thermoplastic material. The booster also defines the nodal points of the  
oscillation movement such that the assembly may be suspended in a  
frame with minimum transfer of vibrations to the frame proper. The  
35 mechanical connection between the transducer and the booster may be a  
purely mechanical installation or a screw or weld connection. The end of

transducer is similarly in mechanical abutment against a sonotrode whose opposite end constitutes the actual work surface which is in contact with the material which is to be sealed. The work surface of the sonotrode is normally in the form of a line which may be straight, angled or curved. It is of course  
5 also possible to realise a punctiform work surface. A feature common to the majority of known applications of ultrasonic welding of thermoplastic packaging materials hitherto is that the work surface is located at a right angle to a centre line extending through the sonotrode, the booster and the transducer. Hereby, the transfer of the ultrasonic vibrations from the  
10 transducer to the sonotrode takes place rectilinearly, which reduces losses and creates relatively few problems in connection with the design of the sonotrode and its work surface, since only axial waves are transferred through the assembly.

In the manufacture of, for example, round, polygonal or conical  
15 packaging containers, it is desirable to realise a closed sealing line which extends throughout the entire circumference of the packaging container. This is, for instance, necessary when a round packaging container is to be provided with end walls or when the circumferential outer casing of a round packaging container is to be connected to a more or less conical upper  
20 section. A closed seal along the circumference of, for example, a cylindrical packaging container may of course be realised using known methods employing a sonotrode with a short, straight work surface, provided that the seal is made in many stages during the simultaneous rotation of the packaging container. However, this technique is time-consuming and does  
25 not always give an adequate result, for which reason it is desirable in the art to provide an annular sonotrode of an inner diameter which substantially corresponds to the outer diameter of the packaging container at the welding site. With the aid of a mandrel located inside the packaging container (the mandrel may be gently conical or expandable), the weldable parts of the  
30 packaging container are pressed against the inner circular work surface of the annular sonotrode, whereafter the ultrasonic transducer is activated such that the sonotrode vibrates at the desired welding frequency. This technique has been tested with limited results. In, for example, US-PS 3.438.824, there is disclosed int. al. an assembly which utilises an annular sonotrode which, via  
35 a booster, is radially connected to a conventional transducer which generates reciprocating oscillations that may be transferred axially through the booster

to the sonotrode. In the annular sonotrode, the oscillations are propagated substantially uniformly about the sonotrode, apart from in the region of the mechanical anchorage between the booster and the sonotrode, where the wave propagation is disrupted by the asymmetry in the anchorage region.

5 The end of the booster facing away from the transducer is mechanically connected by a screw connection directly to the outer, circular peripheral surface of the sonotrode which, in ultrasonic welding, has proved to cause powerful thermal generation at the anchorage point. The generation of such heat is because the conversion of the axial reciprocating movement into

10 radial waves in the annular sonotrode also creates transverse movements, i.e. the radial oscillations in the sonotrode will also have a component which extends in the circumferential direction of the sonotrode and is in the form of compressions and decompressions of the material of the annulus, which directly affects the anchorage point of the booster in the sonotrode in the

15 transverse direction so that friction occurs in the contact surfaces, and not only the threaded area but also other points of abutment are heated. In such instance, losses occur which give the assembly a lower degree of efficiency and also entail a risk of crack formation at the anchorage region. Even though this problem need not be serious in individual welds at relatively

20 low power outputs, it will rapidly create serious problems, when an assembly of this type is employed for the welding of circular packaging containers in connection with commercial, high capacity manufacture. It has hitherto not been possible to solve this problem satisfactorily, and assemblies of the type described in the above US patent have, as a result, not been put to

25 any major commercial use. Closed or annular sonotrodes are also employed for purposes such as the treatment of fluids, for example liquids that are led through the annular sonotrode for the purpose of using ultrasonic waves, for example, to homogenise fluids, to comminute particles, to release gases etc. Also in this field of application, the drawbacks inherent in the previously

30 described prior art designs and constructions are manifest. Thus, there is a general need in the art to realise an ultrasonic assembly of the closed or annular type, this assembly being of such design and construction as to make optimum use of the energy supplied and obviate the risks of losses and crack formation or other damage to the assembly proper.

## OBJECTS OF THE INVENTION

One object of the present invention is thus to realise an ultrasonic assembly which includes at least one transducer and one sonotrode which are interconnected to one another in such a manner that the generated  
5 ultrasonic waves do not entail any negative effect on the assembly.

A further object of the present invention is to realise an assembly of the ultrasonic type which is of such design and construction that the connection point between the transducer and the sonotrode or alternatively a booster located between the transducer and the sonotrode is of such design  
10 that energy losses are avoided as far as is possible.

Yet a further object of the present invention is to realise an assembly of the ultrasonic type in which an annular sonotrode is of such configuration that the transfer point for the ultrasonic waves to the sonotrode is not subjected to unnecessary stresses.

15 Still a further object of the present invention is to realise an assembly of the ultrasonic type which is of simple and reliable design and construction and, as a result, is relatively economical to manufacture and maintain.

Yet a further object of the present invention is finally to realise a welding assembly of the ultrasonic type for closed sealing, the welding  
20 assembly being of a design and construction which obviate the above-outlined drawbacks and ensure rapid and reliable welding eminently suited for use together with high capacity packing and filling machines.

## SOLUTION

25 The above and other objects have been attained according to the present invention in that an ultrasonic assembly of the type disclosed by way of introduction has been given the characterizing features as set forth in the appended main Claim.

Preferred embodiments of the assembly according to the present  
30 invention have further been given the characterizing features as set forth in the appended subclaims.

## ADVANTAGES

By using the adapter portion integrated in the sonotrode to displace  
35 the contact surface between the sonotrode and the booster in a direction away from the annular portion of the sonotrode, the harmful effects of the

vibrations on the mechanical connection point between the booster and the sonotrode will be reduced considerably. The pressure waves in the circumferential direction of the sonotrode (compression and decompression waves) are transferred to only a limited degree at the waist adapter portion, which largely eliminates transverse pressure components and thereby also frictional heating or other harmful effects in the mechanical connection point. The displacement of this point from the annular portion also entails a reduction in disruptions in the oscillation pattern of the sonotrode annulus, which results in a more uniform power output distribution and thereby an improved work result.

### BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

One preferred embodiment of the assembly according to the present invention will now be described in greater detail hereinbelow, with particular reference to the accompanying, schematic Drawings, which show only those details essential to an understanding of the present invention. In the accompanying Drawings:

Fig. 1 is a perspective view of the front end of an ultrasonic assembly with an annular sonotrode according to the invention;

Fig. 2 is a schematic side elevation, partly in section, of an ultrasonic assembly with an abutment for welding circular packaging containers; and

Fig. 3 is, on a larger scale, a top plan view of the sonotrode according to the present invention illustrated in Figs. 1 and 2.

### DESCRIPTION OF PREFERRED EMBODIMENT

The ultrasonic assembly according to the present invention is, in its preferred embodiment, intended for the welding together of packaging container parts of annular or circular cross section, which is a typical example of the practical application of ultrasonic welding techniques within the packaging industry. The packaging container may of course have other cross sectional configuration, for example be oval, rectangular or hexagonal, or the like. One precondition for ultrasonic techniques to be applicable for the welding together of materials is that at least one of the material layers included comprises a material which may be plastified by ultrasonic waves. In practice the packaging container (in any event those which are intended for wholly or partly liquid contents) includes layers of thermoplastic

material, which is extremely well suited for ultrasonic welding. The material layers which are to be united to one another must, in such instance, include a contact surface which contains thermoplastic material, for example polyethylene, which makes it possible - preferably after compression of the two material layers against the work surface of the welding assembly using some form of abutment - to vibrate the material so that the thermoplastic layer is plastified and fuses together in order, on completed ultrasonic heating, once again to cool and harden, whereupon it functions as a glue or bonding agent which permanently unites the packaging container parts to one another in liquid-tight fashion. However, this technique is well-known, for example, from the above-mentioned US-PS 3.438.824, to which reference is now made, and need not therefore be described in detail in this context.

Fig. 2 shows an ultrasonic assembly 1 according to the invention. The assembly 1 includes an ultrasonic generator or transducer 2 of known type which, for example by means of a piezoelectric crystal, converts electric current variations into a mechanical movement in the form of reciprocating ultrasonic waves which, in the described practical application, i.e. the welding of paper/plastic packaging materials, typically has a frequency range of approx. 16-24, preferably 20 KHz. The transducer 2 which, in a known (not shown) manner, is connected to a current source, is also mechanically connected to a booster 3 for amplifying or converting the ultrasonic waves generated by the transducer 2. The booster 3 also defines the nodal point of the waves and is utilised in a conventional manner also for suspension of the welding assembly 1 in a frame (not shown). At the end of the booster 3 facing away from the transducer 2, there is a closed or annular sonotrode 4 which is mechanically connected to the booster 3 and is thus drivable by means of the transducer 2 so that an inner work surface 5 is subjected to radial ultrasonic vibrations. A similar construction may also be employed, for example, for treating fluids which are led through the closed (annular) sonotrode. On material welding however, use is also made (Fig. 2) of an expandable mandrel 6 which has a circular work surface 7 which is intended for cooperation with the work surface 5 and which consists of a number of resilient segments 8 which, with the aid of inner cone 9, may be reciprocated radially by means of concentrically disposed operating shafts 10 and 11. Fig. 2 also illustrates how two packaging container parts, namely a casing 12 and a top 13 which are to be connected to one another, are moved

to the welding position, as will be described in greater detail below.

Fig. 1 is a perspective view of the sonotrode 4 which, as was mentioned previously, is of the closed type, i.e. annular or circular and has a substantially quadratic cross section. The inner work surface 5 of the sonotrode 4 is thus circular-cylindrical and is of a diameter which slightly exceeds the outer diameter of the casing 12 (the top 13 is welded internally in the upper end of the casing 12). As was mentioned above, the sonotrode 4 is mechanically united with the booster 3 and, more precisely, with the front end of the booster facing away from the transducer 2, this end being provided with means (not shown) for configurationally stable engagement with an anchorage device 14 projecting out from the outside of the sonotrode (Fig. 3). More precisely, the anchorage device 14 consists of a part of an adapter portion 15 radially projecting from the sonotrode 4, the adapter portion 15 also including, apart from the anchorage device 14, a projection 16 located between the anchorage device 14 and the annular portion of the sonotrode 4. At its end facing towards the annular portion of the sonotrode 4, the projection 16 has a region of reduced cross sectional area, which manifests itself as a waist 17 which forms the connecting portion of the adapter portion 15 with the annular portion of the sonotrode 4. At its end facing away from the cylindrical portion of the sonotrode 4, the projection 16 has a planar abutment surface 18 which is intended to cooperate with and abut against the front, planar end of the booster 3 (only indicated in Fig. 3). The anchorage device 14 which projects from the surface 18 is provided with means for configurationally stable engagement with the booster 3 in the form of a thread 19 which cooperates with a corresponding thread in a threaded hole (not shown) centrally provided in the front end of the booster 3. An alternative possibility is of course to produce the booster 3 and sonotrode in one piece with substantially retained geometric architecture, which, for example, in certain practical applications and smaller sizes (for example in liquid treatment), may be preferred. In such an event, the unit may, for instance, be manufactured from powdered metallic material. In this case, the "booster" 3 more precisely corresponds to an enlarged (lengthened) projection 16 and is provided in a corresponding manner with anchorage devices for mechanical connection to the transducer at its end facing away from the sonotrode.

The annular portion of the sonotrode 4 has, as has been described in

the foregoing, a circular-cylindrical inner work surface 5 whose diameter substantially corresponds to the outer diameter of that packaging container which the assembly is intended to process. In the illustrated embodiment, the inner diameter of the sonotrode 4 is approx. 66 mm, while its outer diameter amounts to approx. 100 mm. Thus, the annular portion of the sonotrode has a rectangular cross section of the dimensions 17 mm (radially) and 20 mm. The projection 16 is 15 mm between the abutment surface 18 and the intended external circular-cylindrical defining surface of the sonotrode. The projection 16 is of rectangular cross sectional configuration with the dimensions 20 x 30 mm, while the area provided with the waist 17 has a cross-sectional dimension measured in the plane of the annular sonotrode 4 amounting to 20 mm.

When the assembly 1 according to the invention as shown in Fig. 2 is activated for welding together of, for example, a casing 12 and a top 13 of a packaging container, these parts are placed with the upper edge region of the casing 12 in abutment against the inner work surface 5 of the sonotrode 4. The top 13 is passed down into the upper end of the casing 12 so that its lower portion intended for welding will be located in register with the upper and lower defining edges of the work surface 5. Hereafter, the mandrel 6 is moved with the aid of the operating shaft 10 vertically upwards until its work surface 7 will likewise be located centrally between the upper and lower ends of the work surface 5, i.e. in register with the centre line illustrated in Fig. 2 extending through the transducer 2, the booster 3 and the sonotrode 4. In this position, the mandrel 6 is activated in that the operating shaft 11 is displaced a short distance vertically downwards, which entails that the cone 9 is moved down a corresponding distance so that its outer, conical surface, by abutment against the interior surfaces of the segments 8, presses the segments outwards so that the work surface 7 consisting of the upper, out portion of the segments 8 is urged against the inside of the top 13, which thereby comes into abutment against the upper end of the casing 12 so that this in its turn is powerfully urged against the work surface 5 of the sonotrode 4. As a result of this well-defined abutment between the work surface 7 and the mandrel 6, the parts 12 and 13 of the packaging container and the work surface 5 of the sonotrode 4, there will be ensured optimum transfer conditions for the ultrasonic energy.

Once the parts intended for welding and the mandrel 6 have thus

been brought to the correct working position, the transducer is activated. Hereby, reciprocating ultrasonic vibrations are generated in a per se known manner, these being propagated via the booster 3 axially along the centre line (Fig. 2) extending through the transducer 2 and the booster 3. As a result of the mechanically stable connection between the front end of the booster 3 and the abutment surface of the sonotrode 4, the axial vibrations are transferred to the annular sonotrode 4 where, because of the geometry of the sonotrode, they are substantially converted into reciprocating wave movements radially directed from the geometric centre of the sonotrode. As a result of the powerful abutment of the top 13 and the casing 12 caused by the mandrel 6 against the work surface 5 of the sonotrode, the radial ultrasonic vibrations are transferred to the parts of the packaging container, which results in a rapid heating of thermoplastic layers included in the parts, so that these are softened and may be fused to one another. When the desired degree of plastification or softening of the thermoplastic layers has been achieved (this normally takes only between 0.2 and 0.6 sec.), the current supply to the transducer 2 is discontinued and the mutually interconnected parts of the packaging container are allowed to cool for a further length of time, whereafter the mandrel 6 is deactivated in that the operating shaft 11 is displaced vertically upwards so that the segments 8 may spring together and the pressure against the work surface 5 of the sonotrode 4 ceases. Hereafter, the mandrel 6 may, with the aid of the operating shaft 10, be displaced vertically downwards to the position illustrated in Fig. 2 and the fused packaging parts may be removed vertically upwards out of the annular sonotrode 4.

On the transfer of the axial ultrasonic waves reciprocating along the centre line of the booster 3 to the annular sonotrode 4, there occurs, because as previously mentioned, of the annular form of the sonotrode, a conversion of the axial waves into radial waves which reciprocate along the radii extending out from the centre of the sonotrode 4. In this instance, the annular sonotrode 4 is dimensioned such that its mean circumference, i.e. the mean value of the outer and inner diameters of the sonotrode 4, corresponds to one wave length of the ultrasound. The movements of the ultrasound generated in the sonotrode 4 may be seen as compression and decompression waves which reciprocate radially from the outer diameter of the sonotrode to the inner diameter of the sonotrode. Since the circumference at the outer

diameter of the sonotrode is greater than the circumference at the mean diameter of the sonotrode, and since correspondingly the circumference at the inner diameter or work surface 5 of the sonotrode is less than the circumference at the mean diameter of the sonotrode, the compression and decompression will cause not only radial but also transverse movements, i.e. movements directed along the circumferential direction of the annulus, which may most closely be described as alternatingly compression and expansion of the annular material (for example titanium). These movements are acceptable along the circumference of the annulus and normally cause no difficulties since the annulus is symmetric, but in conventional screw connections between the booster and the sonotrode at the outer diameter of the sonotrode, the radial waves will give transverse components which create material movements in the thread region and can lead to heating and to negative effects on the materials, e.g. in lengthy operation, crack formation or the like. The adapter portion 15 according to the invention reduces these negative effects by limiting the transfer of the radial waves which do not follow a plane extending along the centre axis of the sonotrode 4 and the transducer 2 from the annular portion of the sonotrode 4 to the adapter portion. While the adapter portion must have a relatively large, planar and stable abutment surface against the booster 3, the cross sectional area between the adapter portion 15 and the annular portion of the sonotrode 4 should theoretically be as little as possible, since it is hereby possible to minimise the area in which the transverse ultrasonic waves act and are transferred. For reasons of mechanical strength, the area cannot be reduced to a point or a line, but, according to the invention, the area of the projection 16 at its end facing towards the sonotrode is reduced with the aid of the waist 17, which gives the projection 16 a waist which limits the harmful effects of the transverse component of the ultrasonic waves.

The provision of the adapter portion 15 entails that the abutment surface 18 and the anchorage device 14 for connecting the sonotrode 4 to the front end of the booster 3 are displaced a greater distance from the annular, active portion of the sonotrode 4. This displacement entails that the effects of the transverse component of the ultrasonic waves on the abutment surface 18 proper and the anchorage device 14 are further reduced, since the amplitude of the waves fades progressively, partly because of the increase in distance from the annular portion of the sonotrode, and partly because of the action

on wave propagation caused by the waist 17. In order to avoid asymmetric influence on the transfer of the axial ultrasonic waves from the transducer 2 via the booster 2 and to the sonotrode 4, it is crucial that the adapter portion extend radially out in relation to the geometric centre of the sonotrode 4. Like the adapter portion 15, the projection 16 is, in its entirety, symmetrically designed (in the plane of the sonotrode annulus) in relation to the radius extending through the centre of the sonotrode 4, which at the same time constitutes the centre axis through the booster 3 and the transducer 2. As has been mentioned earlier, the adapter portion has, on the other hand, varying cross sectional configuration along this radius and the major principle is that the projection 16 is to have a region of greater cross sectional area a distance from the centre of the sonotrode 4, and also a region of lesser cross sectional area at the end of the projection 16 facing towards the centre of the sonotrode 4. Theoretically, the smallest cross sectional area should be located most proximal the outer, annular defining surface of the sonotrode 4, but in practice it is necessary, for reasons of mechanical strength, to provide the transitional region between the adapter portion 15 and the annular portion of the sonotrode 4 with the waist 17.

In order to reduce the harmful effects of the vibrations, above all in a transverse direction, which nevertheless unavoidably reach both the adapter portion 15 and the anchorage device 14, it is vital that the adapter portion 15 be of one piece manufacture with the annular portion of the sonotrode 4. It is thus not possible to provide the sonotrode 4 with an anchorage device, for example a threaded connection, at the region of the waist 17, and it has also proved that soldering or welding in this region is exposed to excessively high stresses by the ultrasound. Naturally, the sonotrode may be connected directly to the front end of the transducer (designed in a suitable manner) if the booster is not to be employed, for example for reasons of space. Thus, that stated above applies in appropriate parts also to an assembly designed without a booster. As has been mentioned above, it may also be possible, in particular in relatively small assemblies, to design the booster and the sonotrode to be of one piece construction, i.e. the booster is as good as integral part radially projecting from the sonotrode. When high power outputs are required, it is also possible to supply the sonotrode from a plurality of ultrasonic assemblies, in which event, for example, three assemblies may be uniformly distributed (120° distribution) and be

connected along the periphery of the sonotrode, which of course must then be provided with a corresponding number of adapter portions.

Hence, the assembly according to the present invention makes it possible to transfer reciprocating, axial ultrasonic vibrations to an annular sonotrode in that the sonotrode is provided with a radially projecting adapter portion which, on the one hand, is of one piece manufacture with the annular portion of the sonotrode 4 and, on the other hand, has a region of reduced surface area at its end facing towards the annular portion of the sonotrode 4, and finally makes possible displacement of the mechanical connection with the front end of the booster to a region more distal from the annular portion of the sonotrode 4. As a result of the sum total of these measures, it will now be possible in practice, under realistic operational conditions and, for example in the production of packaging containers on a large industrial scale, to utilise an annular sonotrode for welding circular packaging containers or for other operational duties on a commercial scale.

The present invention should not be considered as restricted to that described above and shown on the Drawings, many modifications being conceivable without departing from the spirit and scope of the appended Claims.

**WHAT IS CLAIMED IS:**

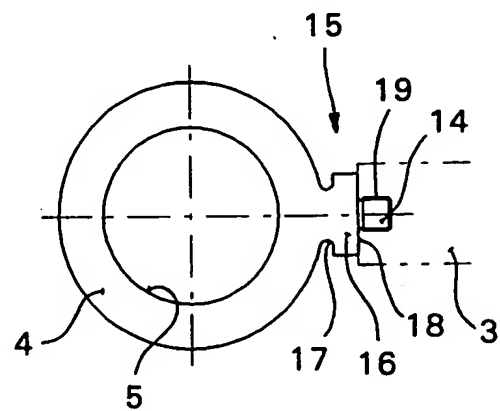
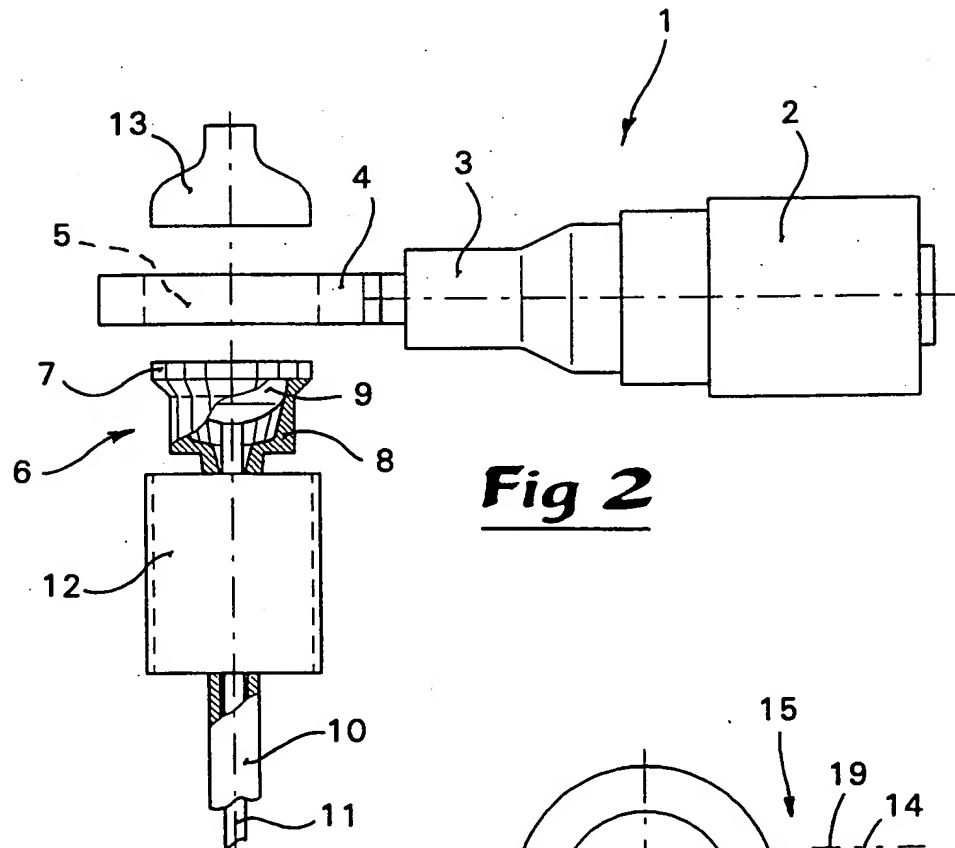
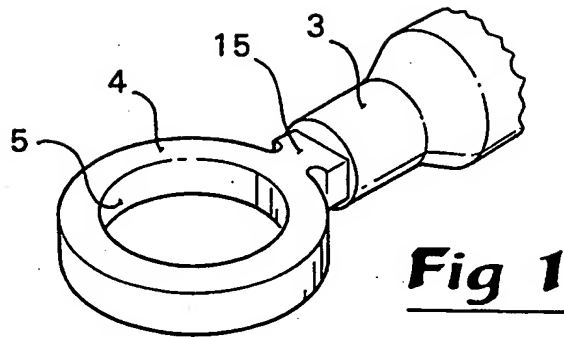
1. An ultrasonic assembly comprising a transducer (2) and a sonotrode (4) characterized in that the sonotrode (4) is annular and has an adapter portion (15) disposed between the transducer (2) and the sonotrode, the adapter portion being in the form of a projection (16) projecting from the sonotrode (4) and displaying, at its end facing away from the sonotrode, an anchorage device (14) for direct or indirect connection to the transducer (2).
2. The assembly as claimed in Claim 1, characterized in that the adapter portion (15) extends radially outwards in relation to the geometric centre of the sonotrode (4).
3. The assembly as claimed in one or more of Claims 1 to 2, characterized in that the projection (16) is symmetrically designed in relation to a radius extending through the sonotrode (4), but displays varying cross sectional configuration along said radius.
4. The assembly as claimed in one or more of Claims 1 to 3, characterized in that the projection (16) has a region of greater cross sectional area and a region of smaller cross sectional area, the latter region being located more proximal the geometric centre of the sonotrode (4) than the former region.
5. The assembly as claimed in one or more of Claims 1 to 4, characterized in that the projection (16) has a region adjacent the annular portion of the sonotrode (4) of reduced cross sectional area.
6. The assembly as claimed in one or more of the preceding Claims, characterized in that the projection (16) is connected to the annular portion of the sonotrode (4) via a waist (17).
7. The assembly as claimed in one or more of the preceding Claims, characterized in that the anchorage device (14) displays means for configurationally stable engagement with adjacent assembly parts.

8. The assembly as claimed in Claim 7, characterized in that the anchorage device (14) includes a thread (19) for releasable interconnection with adjacent assembly parts.

5 9. The assembly as claimed in one or more of the preceding Claims, characterized in that the adapter portion (15) is of one piece manufacture with the sonotrode (4).

10 10. The assembly as claimed in one or more of the preceding Claims, characterized in that a booster (3) is disposed between the transducer (2) and the sonotrode (4), the adapter portion (15) being mechanically connected to the end of the booster (3) facing away from the transducer (2).

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A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 B06B3/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B06B B29C B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 074 152 A (ASAI KIYOKAZU ET AL) 14 February 1978 see column 31, line 53 - column 32, line 48; figures 27-29 ----	1-10
X	K.ASAI ET AL: "A new hollow cylindrical ultrasonic wave radiator" JAPANESE JOURNAL OF APPLIED PHYSICS, SUPPLEMENTS., vol. 20, no. 20-3, - 1981 pages 169-172, XP002077231 TOKYO JA see figure 2 ----	1-10
A	US 3 438 824 A (BALAMUTH LEWIS) 15 April 1969 cited in the application -----	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

11 September 1998

Date of mailing of the international search report

24/09/1998

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4074152	A	14-02-1978	JP 51078317 A 07-07-1976
			JP 1114371 C 29-09-1982
			JP 52026213 A 26-02-1977
			JP 57007792 B 12-02-1982
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US 3438824	A	15-04-1969	NONE

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